

Impacts of Climate Change on Long Island Sound Salt Marshes

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Focus

The natural and anthropogenic impacts of climate change on salt marshes.

Focus Question

How are scientists in our region studying the various impacts of climate change on salt marsh habitat?

Audience

9th/10th grade Biology or General Science students as well as upper level science elective courses such as Environmental Science or Marine Science, as appropriate.



Salt marshes are critical habitats at the interface of land and sea that fringe the Long Island Sound. Photo: B. Lawrence

Learning Objectives

Students will obtain an overview of a variety of different techniques for climate change research.

Students will describe carbon- and nitrogen-based services associated with dominant coastal marsh plant species.

Students will identify that shifts in dominant marsh species will alter ecosystem service provision of Long Island Sound coastal wetlands.

Students will gain an understanding of the complex interactions among climate change, sea level rise, coastal wetlands, and ecosystem services among diverse audiences in the Long Island Sound region.

Materials

- Computer or individual 'smart' device
- EdPuzzle account
- Case Study handout & PowerPoint
- Drowned sparrow nest & viable sparrow nest printed (recommend images printed on opposite sides and laminated if possible)
- LCD/Projector with audio

- Interactive PowerPoint guided notes worksheet
- Mystery Scientist guided notes worksheet
- CER student worksheet

Audio/Visual Equipment

Computers/Internet access

LCD for PowerPoint presentation (audio required)

Teaching Time

Five teaching periods/days estimating a 45 min class duration. Teachers with block scheduling will be able to complete the unit in three class meetings.

Seating Arrangement

Students will work in small groups of 4 - 5, in pairs and individually over the course of the unit.

Key Words

Anthropogenic

Biodiversity

Biogeochemistry

Carbon and Carbon Sequestration

Ecosystem Services

Greenhouse Effect

Greenhouse Gas

Invasive Species

Nitrogen and Denitrification

Photon

Vegetation

Salt Marshes

Wetlands

Background Information/Teacher Preparation

- Teachers should be familiar with the basics of climate change and what causes it. The climate change video used in the EdPuzzle is a good primer for teachers as well as students.
- Additional background for the “Polar Bear of the Salt Marsh” is included with the case study.
- Explanation and examples are provided for the Claim, Evidence and Reasoning technique with the unit materials.

Learning Procedure



Summary:

- Day 1 should be used to pre-teach or refresh students about the basics of climate change they will need to understand to meet the learning objectives of this module by completing The Greenhouse Effect PHET.
- Day 2 should be used to conduct the Polar Bear of the Salt Marsh case study parts 1, 2 and 3.
- Day 3 should be used to generate student interest and discussion (phenomenon) with the drowned sparrow warm up activity followed by the lead researcher's interactive Powerpoint.
- Day 4 should be used to conduct the Mystery Scientist Activity.
- Day 5 should be used to complete the unit assessment CER based on the Mystery Scientist Activity.

Procedure:

Note- all handouts associated with module materials are provided after page 7, but can also be downloaded via provided links. Teacher materials (including teaching notes and answer keys) can be accessed via the links in the table below.

<u>Time line</u> (*45 min periods)	<u>Content Covered</u>	<u>Materials</u>
Pre-work	Basic review of climate change. EdPuzzle - free for students and teachers.	Review video of climate change: <ul style="list-style-type: none"> • https://youtu.be/XFmovUAWQ640423867UQ EdPuzzle: https://edpuzzle.com/media/5d5d7378ef145440951f9ea4
Day 1	Essential information to pre-teach, or refresh students about the basics of climate change they will need to understand to meet the learning objectives of this module. Climate Change: what is it & causes of. Potential activity/discussions: -The Greenhouse Effect PHET (for classrooms with computer access) - See PHET site for additional optional support materials (ie- worksheets & diagrams) -Review results of EdPuzzle questions with students	Interactive Simulations: https://phet.colorado.edu/en/simulation/greenhouse

Day 2	Case Study Parts 1 -> 3 : “The Polar Bear of the Salt Marsh?” from National Center for Case Study Teaching in Science	<ul style="list-style-type: none"> • Case Study Link: http://sciencecases.lib.buffalo.edu/collection/detail.html?case_id=1011&id=1011 • Teaching notes and answer key posted here: <ul style="list-style-type: none"> • saltmarsh_sparrow_teachingnotes.pdf • saltmarsh_sparrow_answer_key.pdf
Day 3	<p>Drowned Sparrow Do-Now/Opener/Warm-Up: Pass out photos of non-drowned (viable) sparrow nest and drowned (non-viable) sparrow nest on opposite sides of a laminated sheet to each lab group for discussion.</p> <p>Interactive Powerpoint by researcher (~25 min) with directed notes: Overview of saltmarshes and scientist’s research</p> <p>Optional extension: NY Times Article</p>	<ul style="list-style-type: none"> • Suggested phenomena: image of baby sparrows in nest and nest drowning. <ul style="list-style-type: none"> • Regular Nest: https://images.app.goo.gl/giN5s4zVkwyzTBfD6 • Drowned Nest:https://www.audubon.org/news/the-saltmarsh-sparrow-creeping-dangerously-close-extinction • Interactive Powerpoint: https://kaltura.uconn.edu/media/HBL-Rec01_bal15101_20190815-151824/1_0e1n3m2j • Interactive directed notes:https://drive.google.com/file/d/1ffQhjOXXoOyqQracOUKV15PwzK6ozA8Q/view?usp=sharing • Answer key: https://docs.google.com/document/d/1g61ZwtfJshZxRBDWfGprTiOOI4ZOmpPHELsmxErypCA/edit?usp=sharing <p>Extension Article: https://www.nytimes.com/2018/09/17/science/saltmarsh-sparrow-extinction.html</p>
Day 4	<p>Mystery Scientist Activity</p> <p>Objectives: “Meet the Scientists”</p> <ul style="list-style-type: none"> • Watch assigned videos in groups of 4-6 (note: there are 5 total Mystery Scientist videos, labeled A-E) • Suggested ideas for sharing results: <ul style="list-style-type: none"> • Jigsaw results with students-each group sharing out to class • Have students fill in results on a large scale table • Matching activity/game-match laminated photos with appropriate scientist 	<ul style="list-style-type: none"> • Mystery Scientist Guided Notes: https://docs.google.com/document/d/1_pu9TZpXp-H0bOys4MMgkoZGbnSU6fy0UXjURNFO9AU/edit?usp=sharing • What do Mystery Scientists Do? Videos:https://www.youtube.com/channel/UCeh-g0Hcgu-z9C-MSq_yeQ/videos

	<p>Closure/HW: 'Ask the Scientist'</p> <ul style="list-style-type: none"> Now that you have learned about what your Mystery Scientist does, if you could talk to them right now, what would you ask or suggest to them about their research? What about their experiments made you wonder or wish you knew more? What more do you want to know about their research? 	
Day 5	<p>Do Now/ Warm Up: Brain storm student question/responses for 'Ask the Scientist'. Optional: teacher email a curated selection to the scientist(s).</p> <p>Video Reveal of Mystery Scientist. (Suggested whole class activity)</p> <p>CER - start in class, finish as HW assignment. Assessed for grading.</p> <p>Introduce focus question. "Is the scientist helping us learn more about climate change?" Pick a scientist from the collection.</p> <p>CER - Students will make a claim using evidence provided to address the question. Evidence taken directly from mystery scientist guided notes. (<i>Crafting your Reasoning document should be downloaded for best viewing. *google doc instructions</i>)</p> <p>Options:</p> <ul style="list-style-type: none"> Group or individual assessment activity. In class or homework assignment. <p>IEP students - provide resources with highlighted preselected evidence/data for them to choose from.</p> <p>Three sample CERs have been provided for classrooms unfamiliar with the Claim Evidence Reasoning technique.</p>	<ul style="list-style-type: none"> Mystery Scientist Identifier videos: https://www.youtube.com/channel/UCqsxQpiOWsXiiJ8anoE6tUw?view_as=subscriber CER outline (student copy): https://drive.google.com/file/d/1KtkD5J4K5ed1Gb6rLYVnuG9uAEbqc99B/view?usp=sharing CER outline with sentence starters: https://drive.google.com/file/d/1sFo8wNjXBoUUCmGxclbMvSIUdcuCr_Hj/view?usp=sharing Crafting your Reasoning: https://drive.google.com/file/d/1Ye2DcM_mITpJshuro21yiA4fPpXUozbZ/view?usp=sharing Sample CER: https://drive.google.com/file/d/1exkapvzwWWhpJt9pqAkEQdwq4aL854G4-/view?usp=sharing Grading Rubric: https://drive.google.com/file/d/1yJeKR3-gWYgGYYPb3SCuOWQf2QpOnobR/view?usp=sharing

The “Me” Connection

- Explain how human development of coastal land has impacted the salt marsh habitat.
- Describe how anthropogenic actions have caused sea level rise.

Connection to Other Subjects

History/Geography, Economics

Evaluation

EdPuzzle answers, Case Study answers, Interactive PowerPoint worksheet, Mystery Scientist guided notes and CER worksheet.

Extensions

Day 3: Read and discuss ‘Saltmarsh Sparrows Fight to Keep Their Heads Above Water’ article published by the NY Times.

Day 4: Utilize the student generated responses to the ‘Ask the Scientist’ activity to email a select number of questions to the researchers who participated in the Mystery Scientist activity videos.

Day 5: Complete the Polar Bear of the Salt Marsh case study (Part 4 & 5)

Resources/Helpful Links:

Review video of climate change:

<https://youtu.be/XFmovUAWQ640423867UQ>

Ocean Literacy Link:

<http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/>

Instructional Resource News Platform: Newsela:

<https://newsela.com/>

LIS Salt marsh response to SLR graphic:

<http://2pywec11qb6ms796h1lfxn1.wpengine.netdna-cdn.com/wp-content/uploads/2015/08/SLAMMdid-you-know-fact-sheet2-V05.pdf>

How LIS was formed (animation):

<https://www.youtube.com/watch?v=eeelgDs4SdY>

Sea Level Rise by State:

<https://sealevelrise.org/states/>

Greenhouse Gas simulator:

<https://phet.colorado.edu/en/simulation/greenhouse>

PHET - Greenhouse Effect

<https://phet.colorado.edu/en/simulation/legacy/greenhouse>

MIT's greenhouse gas simulator:

<https://www.climateinteractive.org/tools/mits-greenhouse-gas-simulator/>

How sun's energy gets to earth's surface:

<https://science360.gov/obj/tkn-video/4ee36f26-71e6-41cd-bdcf-662c4dca6e9b/earths-heat-balance-suns-energy>

Greenhouse Gas Activities:

<https://authoring.concord.org/sequences/388>

Scientific Inquiry, Literacy and Numeracy

- Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena.
- Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation.
- Scientific inquiry requires the sharing of findings and ideas for critical review by colleagues and other scientists.
- Scientific literacy includes speaking, listening, presenting, interpreting, reading and writing about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.
- Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas.

Next Generation Science Standards

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6: The ocean and humans are inextricably interconnected
Fundamental concept e: Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

The Polar Bear of the Salt Marsh?

by

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Part I – What’s Going On?

Katie was horrified. A sudden feeling of unease overtook her. Looking at the drowned nestlings floating in a tangle of saltmarsh grass made her sick to her stomach. This was the fifth drowned saltmarsh sparrow nest she had discovered this breeding season. Katie had been exploring the wetland adjacent to her house in coastal Connecticut since her dad had given her a set of binoculars for her eighth birthday ten years ago. A competent naturalist, she knew that saltmarsh sparrows were ground-nesting birds, endemic to the tidal marshes of the eastern United States and were decreasing in population size throughout southern New England. She noted another drowned nest in her field notebook and asked herself, *What could be going on here?*

Question

1. What factors could lead to drowned nests in a tidal salt marsh?

Part II – Rising Sea Levels

Since it was low tide, Katie decided to tromp through the marsh to the Barn Island Wildlife Management Area headquarters to see if she could talk with somebody who might have more information. Different salt marsh plants can tolerate different amounts of flooding and salt concentrations. This variation in physical stress tolerance leads to vegetation zones or bands, each dominated by different grass-like plants. Katie traversed the band of vegetation closest to the ocean where cordgrass (*Spartina alterniflora*) exclusively dominates the daily flooded low-marsh elevations. In southern New England salt marshes, marsh hay (*Spartina patens*) dominates the intermediately flooded band, and black rush (*Juncus gerardii*) occupies the higher, drier, and less salty marsh elevations. Marsh hay and black rush are excluded from the low marsh by low soil oxygen levels and high salt concentrations. Cordgrass has the ability to oxygenate its root zone and has physiological adaptations to deal with high salinity, allowing it to tolerate the frequently flooded and salty low-marsh zone.

After a hot slog through the marsh, Katie was relieved to arrive at the Barn Island headquarters and see Chris Smith, a natural resource manager for the Connecticut Department of Energy and Environmental Protection (DEEP). Katie blurted out, “Chris, I found another drowned nest of saltmarsh sparrows this afternoon. That’s the fifth one this season! Have you heard reports from other people like this?”

Chris laughed, “Hi Katie, nice to see you too.” In a more serious tone, he added, “Actually, I’ve had several birders report nest drownings this breeding season, and it seems like more and more are documented each year.” Chris was thoughtful for a moment and then pulled out a recent issue of a preeminent scientific journal and said, “Check out this article. Maybe there’s something in here.”

“Wow, I didn’t know global mean sea-level has risen 14–22cm in the last century. That’s crazy!” exclaimed Katie as she skimmed the article. “Actually, their models suggest that about 70% of sea-level rise since 1970 is attributable to human activities, especially greenhouse gas emissions.”

Chris responds, “So sea levels are rising, but I’m unclear how...”

As Katie continued reading the article she responded, “The two biggest contributors to sea-level rise are thermal expansion of the oceans—as water warms, it takes up more volume—and glacier mass loss. Basically, the earth is warming up due to our use of fossil fuels and causing water to expand and ice to melt.” Katie continued, “But what’s going on in Connecticut? Is that what’s drowning all these saltmarsh sparrow nests?”

Questions

2. What kind of information, either biotic or abiotic, could Katie and Chris use to determine whether sea-level rise is occurring in salt marshes in Connecticut?
3. Sea-level rise of 14–22 cm over 100 years may not seem like much (1.4–2.2mm per year), but consider how the slope of the land determines how much will be inundated. Will steeply or gently sloped areas be more impacted? Try sketching the two situations.
4. Make a diagram showing the three dominant vegetation zones of the salt marsh, indicating relative elevation and distance to the ocean. Based on salt and flooding tolerance thresholds of the dominant plant species, predict how plants will shift in response to sea-level rise; show this on your diagram.

Part III – Vegetation

“There’s a researcher at the University of Connecticut that monitored vegetation in 55, 1-hectare plots in 12 different salt marsh complexes along the Connecticut coastline in 2003 and 2013,” Chris said pensively. “I wonder whether we could determine if sea-level is rising here by comparing the change in occurrence of the different plant species.”

Katie jumped at the suggestion and exclaimed, “Let’s do it!”

Question

5. Do the data in Figure 1 provide support for rising sea levels in coastal Connecticut? Why or why not? What other information would support this hypothesis?

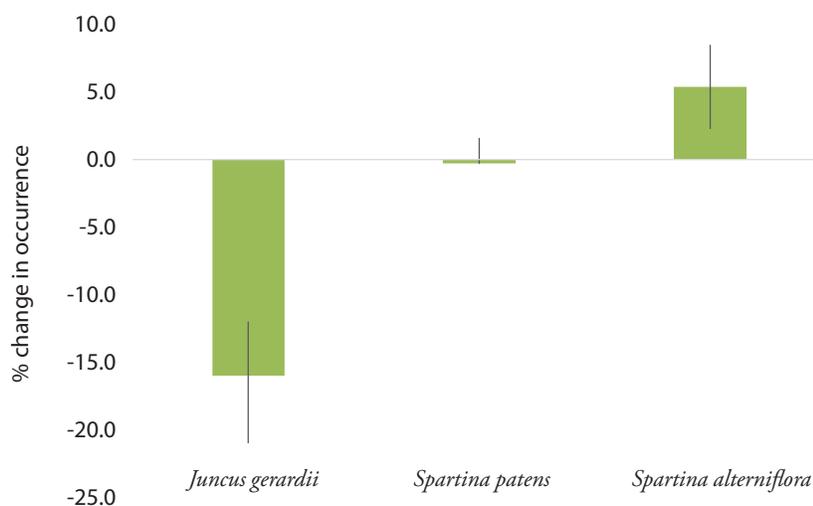


Figure 1. Mean percentage change in occurrence for the dominant plant species in 55, 1-ha plots in Connecticut salt marshes surveyed in 2003 and 2013 (data adapted from Field *et al.*, 2016).

Part IV – The Future

While Katie was data crunching, Chris looked into the literature and found that sea-level rise in southern New England is predicted to be much higher than the global average (Yin *et al.*, 2009; Boon, 2012; Sallenger *et al.*, 2012). Observed sea-level trends at tide stations in southern New England range from 2.44 to 2.87 mm/year over the past 50 years (NOAA; www.tidesandcurrents.noaa.gov) and from 1980 to 2009 increases in the rate of sea-level rise have been 3–4 times the global average (Sallenger *et al.*, 2012). Even with no future carbon emissions, coastal areas face over 0.5 m of sea-level rise over the next century, with more than 1 m possible (Schaeffer *et al.*, 2012).

“Yikes!” exclaimed Katie. “Well, couldn’t saltmarsh plants move in response to increased flooding? Can’t we just expect marshes to migrate landward?”

Chris responded, “Maybe. Let’s look at some satellite images of coastal Connecticut and think about it.”

Question

6. Brainstorm three potential challenges to marsh migration.

References

- Boon, J.D. 2012. Evidence of sea level acceleration at US and Canadian tide stations, Atlantic Coast, North America. *Journal of Coastal Research* 28(6): 1437–45.
- Field, C.R., C. Gjerdrum, and C.S. Elphick. 2016. Forest resistance to sea-level rise prevents landward migration of tidal marsh. *Biological Conservation* 201: 363–9.
- Sallenger, Jr, A.H., K.S. Doran, and P.A. Howd. 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Nature Climate Change* 2(12): 884.
- Schaeffer, M., W. Hare, S. Rahmstorf, and M. Vermeer. 2012. Long-term sea-level rise implied by 1.5 C and 2 C warming levels. *Nature Climate Change* 2(12): 867.
- Yin, J., M.E. Schlesinger, and R.J. Stouffer. 2009. Model projections of rapid sea-level rise on the northeast coast of the United States. *Nature Geoscience* 2: 262–6.

Part V – How to Respond?

Imagine that you own a \$1.5 million house in Old Saybrook in the marsh migration zone. What would you do in the face of sea-level rise?

You will be assigned one of the following five sea-level response strategies to research for the next class meeting. Spend about thirty minutes researching your assigned strategy and develop a list of pros and cons and bring it with you to class next time.

- Beach nourishment
- Sea wall construction
- Conservation easement
- Sell property
- Put house on stilts (adaptation)

You will share your list with others so make sure that you are prepared!

Interactive Directed Notes on Salt Marsh Scientist Talk

Name: _____ Date: _____ Class: _____

Interactive Directed Notes on the Salt Marsh Scientist Talk

Link to interactive Powerpoint: https://kaltura.uconn.edu/media/HBL-Rec01_bal15101_20190815-151824/1_0e1n3m2j

THINK - PAIR - SHARE
Why are coastal marshes important?
...did you miss anything important? Use the space below!

COMPARE and CONTRAST	
Compare and contrast Carbon and Nitrogen-based ecosystem services provided by salt marshes.	
COMPARE (What is similar?)	CONTRAST (What is different?)

BRAINSTORM

The narrator reviewed some of the reasons wetlands have been lost. Brainstorm TWO ways they can be restored.

1.

2.

NOTES

What is the BIG question? (What is the research question?)

THINK LIKE A SCIENTIST

The researchers sampled three plots in each zone and 20 different sites. Why did the researchers sample so many sites?

FIVE SENTENCE ESSAY

What should we do with the invasive grass the researchers analyzed? Support your response with evidence from the presentation!

Mystery Scientist Guided Notes

Name: _____ Date: _____ Class: _____

Mystery Scientist Guided Notes

Directions: Watch the 'mystery scientist' video you have been assigned to answer the questions below. Your answers do NOT need to be in complete sentences, bullet points are fine. Your task is to make notes on this information to help you with a future challenge! HINT: put the captions on the video to help your team.

What part of sea level rise or climate change does this scientist study?

What parts of the ecosystem is this scientist focused on? Ex: sediment, water chemistry, grasses, fish, birds, etc.

WHY is this scientist focused on this in particular (why is it important)?

Mystery Scientist Guided Notes

How do they do their research? Ex: observational studies, experiments, etc.

What type of equipment they use? Ex: quadrat frames, mist nets, satellite imagery, etc.

How is their research currently being used (or could be used)?

Claim-Evidence-Reasoning (C-E-R)

Student Graphic Organizer

Question: Is the scientist helping us learn more about climate change?

****Use your Mystery Scientist Guided Notes!**

<p style="text-align: center;">C</p> <p style="text-align: center;">(Claim)</p> <p>Write a statement that responds to the question.</p>	
<p style="text-align: center;">E</p> <p style="text-align: center;">(Evidence)</p> <p>Provide information from your the video to support your claim. Your evidence should be appropriate (relevant) and sufficient (enough to convince someone that your claim is correct).</p> <p>Bullet points or sentences.</p>	
<p style="text-align: center;">R</p> <p style="text-align: center;">(Reasoning)</p> <p>Use scientific principles and knowledge that you have about the topic to explain <u>why</u> your evidence (data) supports your claim.</p> <p>In other words, explain how the information you chose from the video helps or doesn't help people learn more about climate change.</p>	